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Costs of Managing Nontimber Resources When Harvesting Timber in the Northern Rockies

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MULTIPLE	0428		
R SQUARE	87	R SQUARE CHANGE	.64687
ADJ	306	F CHANGE	46.84179
ST		SIGNIF F CHANGE	.0000

ANALYSIS OF VARIANCE

	DF	SUM OF SQUARES	MEAN SQUARE
REGRESSION	7	9430.00995	1347.14428
RESIDUAL	179	5147.94181	28.75945

F = 46.84179 SIGNIF F = .0000

VARIABLE	B	SE B	95% CONFDNCE INTRVL B	
OBJFOOD	1.51892	.86371	-.18545	3.22329
RDWID	-2.42929	1.05312	-4.50742	-.35117
PAVEHAUL	.38058	.02437	.332 8	.4286
RDGRAD	.80485	.17870	.45	
WPDE	1.69679	.98355		
LOGM	.22787	.05645		
UNPAVE	.50194	.04326		
(CONSTANT)	-4.93842	2.55665		

THE AUTHORS

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RESEARCH SUMMARY

When National Forest Timber is sold, land managers are required to protect other forest resources such as wildlife, soil and water, and scenic qualities. Measures taken to protect nontimber resources can raise administrative costs, lower the quantity of timber sold, and can reduce stumpage receipts. The costs of sale administration and the reduction in timber harvested can be readily derived from accounting and planning records. But little information is available on how much nontimber resources cost in terms of stumpage receipts. To provide such information, some 187 timber sales were studied on seven National Forests in the Northern Region between 1975 and 1981. The study focused on the questions: How do nontimber requirements and objectives affect, first, the appraisal costs allowed in deriving the stumpage value? And second, how do they affect the margin the purchaser bids over and above the estimated stumpage value?

Timber sale folders provided extensive data on characteristics of the sale area and harvesting techniques, and also on general nontimber requirements and specific activities made to meet nontimber goals. Stepwise regression analysis was used to identify those nontimber concerns that were significant in logging costs and bid margins.

These analyses estimated that, in terms of 1980 dollars, the average logging cost allowance for nontimber considerations was $18 per thousand board feet (M bd ft), and bid margins were reduced by another $8/M bd ft, for a total cost of $26/M bd ft for meeting nontimber resource management concerns. This $26 represents about 18 percent of the average logging cost of $144; or in terms of stumpage values, about one quarter of the average $107/M bd ft purchasers paid for the sales used in the analyses.

We made alternative analyses with different assumptions as to how nontimber concerns are considered, but the resulting estimates were similar, ranging from $24 to $26/M bd ft for meeting nontimber goals.

Protecting soil and water and wildlife resources, particularly deer and elk, were the most important nontimber goals. Road construction, sale layout, and harvesting practices were the activities most frequently modified to protect nontimber resources. There was, however, considerable variation among timber sales as to the nontimber provisions undertaken and the costs incurred for them. Furthermore, current and future timber sales may differ from those in the sample. As management policies change and timber harvesting practices evolve, more experience and efficiency is gained in meeting nontimber objectives in timber sales.

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INTRODUCTION

On National Forests, the management of all resources is closely tied to the timber harvesting program. Nontimber resources—forage, wildlife, water, and scenic qualities—may require measures to protect them from degradation or to improve and enhance their value (Schuster and others 1984). The past two decades have seen a substantial increase in provisions to protect the environment and to manage the National Forests for all resources. There has also been a growing concern about management costs and effective use of public money.

The Forest and Rangeland Renewable Resources Planning Act (1974) directs the Forest Service to identify costs and benefits, and to conduct economic analyses of the management of both timber and nontimber resources. Often, however, information needed for such analyses is lacking. Gathering information on costs and values and incorporating these into management planning and programs have involved a substantial (and continuing) effort by planners, managers, researchers, and special study teams.

Much of the forest land in the Northern Rockies is on moderately steep land where harvesting must be designed to protect soil and water. Scenic and recreational values are important, too, and virtually all forest land is habitat for many wildlife species. It is generally believed that, all other things being equal, measures taken to protect or enhance nontimber resources will raise harvesting costs per unit of timber cut. These cost increases in turn lower receipts in dollars per thousand board feet ($/M bd ft) received for the timber. Clearly, "How much lower?" is an important question, but it is not easily answered.

Three categories of costs influence how nontimber concerns affect Forest Service timber sales: administrative costs, opportunity costs, and actual logging costs. Administrative costs are those incurred in preparing and overseeing the timber sale. Budgets and accounting records used by the Forest Service may show direct expenditures for a nontimber resource, but do not necessarily reflect the total effect the activity or requirement has had on harvesting costs, particularly at the project level, such as a timber sale. For example, the timber sale records may show costs of a wildlife biologist's time and supplies for identifying and marking snags for den or nest trees as a rather small, direct wildlife expenditure. But protecting those snags while yarding logs and treating slash may prove to be more costly than marking them. The costs allowed for yarding may therefore be unusually high, but the timber sale appraisal would not indicate why.

Opportunity costs are costs generated by forgoing certain actions that would maximize income. For example, if a patch of timber is not harvested because it is on an elk calving ground, or a strip of timber is left for streamside protection, the value of the timber not harvested is an opportunity cost. Both administrative costs and opportunity costs are important considerations in evaluating nontimber costs, but they are not addressed in this study. Costs analyzed in this study are those associated with logging and related activities. Because costs incurred in logging are reflected in the stumpage value received by the Forest Service, any cost increases due to nontimber considerations may result in reduced stumpage values. Thus reduced stumpage value is one means by which the Forest Service pays for maintaining nontimber resources.

Nontimber goals can profoundly influence stumpage values. Stumpage value is based on the wholesale price of lumber (or other product) less the costs of manufacturing the product and costs of logging—getting the logs from the stump to the mill. If a nontimber objective is expected to increase logging costs, an appropriate allowance is made.

Nontimber requirements can also affect what purchasers actually bid for stumpage. The appraised stumpage value has been estimated by subtracting manufacturing and logging costs from lumber selling price. But in competing for the sale the purchaser may bid more than this value to get the sale. The difference between the appraised value and the actual bid is the bid premium. If the purchaser feels that nontimber provisions will actually cost him more than the appraisal has allowed, he may reduce his bid difference. This reduction is actually a cost to the seller (Forest Service) because it reduces receipts. (Conversely, if the purchaser thinks that the appraisal allowance for nontimber requirements is greater than what it may actually cost him, he may increase his bid difference.)

There are differences in these two aspects of costs that should be noted in the analyses that follow. Allowances for logging costs include all of the principal factors that logically affect logging costs: characteristics of the timber

sale area, logging methods, and various nontimber considerations. Analysis of bid differences is based on the timber sale characteristics, logging methods, and nontimber considerations. Other factors not related to logging may also affect bid difference. These include purchaser's expectation of markets, the urgency of his need for logs, and his bidding strategy relative to other buyers. Although we recognize the importance of such factors, appropriate data were not available, and thus could not be included in the analysis.

STUDY SCOPE AND METHODS

Records of recent timber sales were analyzed to determine whether the variations in harvesting costs are related to the presence (or absence) of activities and requirements to manage nontimber resources. The study covered seven National Forests in western Montana and northern Idaho. A random sample of 187 sales conducted between 1975 and 1981 comprised the data base. Sales during this period conformed to laws and administrative regulations requiring consideration of nontimber values. The sales were selected from those of about 2 million bd ft and larger (smaller sales are less likely to include a full range of nontimber resources). The timber sale files at each Forest Supervisor's office were examined and extensive data were recorded for the analysis. Data included descriptive information (size, silvicultural characteristics, and so on) and qualitative and quantitative measures of various operations, methods, and nontimber resources involved. All costs had been adjusted to 1980 dollars for use in a separate study (Merzenich 1985), using the GNP implicit price deflator.

Measuring Costs

The logging costs analyzed in this study include most of those on the timber appraisal forms used in sale preparation. Costs are expressed as dollars per thousand board feet ($/M bd ft), the form in which costs are estimated in timber appraisals. The logging costs from the 187 sample sales were as follows:

	Mean	Range
	$/M bd ft	
Felling and bucking	22.86	12.59 to 59.14
Skidding and loading	46.32	23.35 to 90.00
Haul	23.42	7.04 to 58.99
Road maintenance	5.48	0.15 to 31.37
Temporary roads	1.03	0 to 15.02
Specified roads	32.52	0 to 112.45
Slash disposal	12.40	0.95 to 41.60

The actual cost incurred by the timber operator may be different from the appraisal cost allowed, but the actual costs are not part of the sale record, and may not be specifically documented even by the operator. The appraised cost is mainly of interest here because it reflects how the appraiser has accounted for the various activities and requirements. The following tabulation shows average lumber price, logging costs, and bid premium for the sales analyzed:

Lumber price, log scale	$340/M bd ft
—manufacturing, profit, misc.	−156
—logging	−144
Appraised stumpage value	$ 40
Purchaser's bid	$107
Bid difference (bid minus indicated)	$ 67

The seven logging cost items and the bid difference are the central subject of the analyses that follow.

Explanatory Variables

Linear regression was used to estimate the relationship between costs and various activities and requirements on the sale. The general model used is

$$Y = \alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_i X_i + \epsilon$$

where Y is the cost in $/M bd ft for different phases of harvesting as indicated in the timber sale appraisal allowance; X_i represents the various sale characteristics, activities, and requirements that are related to these costs; b_i is the regression coefficient, and its estimation is the focus of this study; α_0 is the constant; and ϵ is the error term. Four kinds of variables were expected to affect harvest costs (a complete listing of variables is in appendix B, tables 16—20):

1. **Site variables** are features of the sale that are mostly given in the sale; on a given site they cannot be altered. The six site variables used in the analysis and their mean values for the sample sales are:

Variable	Mean
Volume per acre harvested, M bd ft	16.0
Logs/M bd ft (a reflection of tree size)	18.0
Roads	
Specified road construction (miles)	6.3
Road reconstruction (miles)	5.6
Hauling	
Paved haul distance (miles)	23.0
Unpaved haul distance (miles)	13.4

2. **Harvest decision variables** are features that are part of every sale and are primarily related to the cutting and removing of logs. Such variables may reflect concerns for timber resources, nontimber resources, or both. The harvest decision variables and their mean values from the sample sales are:

Variable	Mean
Cutting method	
Clearcut (including seed tree and right of way)	38.3% of area
Partial cut—individual tree mark, shelterwood, etc.	59.0% of area
Group selection	2.4% of area
Yarding method	
Tractor	62.9% of area
Jammer	18.1% of area
Skyline	17.7% of area
Total area harvested	540 acres
Size of cutting unit	50 acres
Number of cutting units	15 units

3. **Nontimber variables** are requirements, objectives, plans, and methods for managing nontimber resources. Such variables are usually described in qualitative terms in narrative statements in the sale folder. We analyzed such statements and sorted the main considerations into one or more categories of nontimber resources. These were:

Soil	Recreation
Water	Visual
Fish	Cultural
Wildlife	Range

Within each of these categories a present/absent (1,0) coding was used to designate the type and extent to which the resource was considered. Three categories of information were used for each of the eight nontimber resources:

Resource Plan—Indicates a nontimber resource was taken into account in the timber sale. For some resources, this was further defined as to type from more specific statements, such as a specific visual quality objective (VQO) or a species of wildlife.

Objective—Indicates the objective intended for a resource, such as protecting a wildlife travel zone, meeting a water budget constraint, and so on.

Activity—Indicates in general terms how the objectives are to be accomplished, such as by modifying sale plans and layout, modifying road layout or construction, and so on.

In total, 102 general nontimber requirements (NTR's) were initially measured. In the analysis some variables were combined where this would improve the data base and enhance the analysis. Factor analysis was used as an intermediate step in selecting the final NTR's used in each logging cost model. All NTR's were measured as being present (1) or absent (0). The mean value for all sample sales therefore indicates the proportion of observations (timber sales) in which the particular NTR item was present. Some examples of these variables, with their code label and proportion of sample sales in which they occurred, are:

	Code	Percent of sales
Recreation considered in plan	RECPLAN	88
Logging modified to protect soil	SOACT3	19
Wildlife plan for deer and elk	WPD&E	66
Visual quality objective specified	VQO	42

4. **Specific activities variables.** Although the NTR's described above reflect the considerations given to each nontimber resource, they do not always indicate specifically what activities were undertaken. We therefore gathered information for a group of variables that we called specific activities. Such variables describe exactly what was done to modify the various phases of the harvesting operation. Some of these activities or requirements may serve several purposes; for example, a strip of timber left along a stream may protect water quality and fish habitat, prevent soil erosion along the streambank, and provide a travel way and cover for wildlife. The nontimber resource involved may not be specified, but the activity and the phase of logging cost it may affect are described. Some examples of these variables and their mean values in the sample sales are:

Example	Mean
Whole-tree logging required	Present on 10% of sales
Directional felling required	67% of harvest area
Maximum road grade allowed	9.2% slope
Seeding trails and landings	22.9 acres per sale
Shaping or feather edge on unit	4.6% of harvest area

These variables were used in their original form (absent [0], present [1], or as continuous scale for measurements such as acres, percentage, etc.). Some of the individual specific activity variables were combined where appropriate.

Regression Models

The variables discussed above were tested in various combinations in the stepwise regression models

$$Y = \alpha_o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_i X_i + \epsilon$$

where X_i's are the variables selected to be tested in a given cost model (felling, hauling, and so on) and b_i the estimated coefficient. Therefore, each variable, X, has its own b_i that represents the estimated change in cost, Y, as X is increased or decreased. Many of the nontimber considerations we expected would increase costs, so β_i was hypothesized to be positive (that is greater than zero): for example, protecting snags for wildlife might be expected to increase slash disposal costs (avoiding knocking over when piling slash). Other variables were expected to decrease costs, and therefore hypothesized to be negative (less than zero). For example, as volume per acre increases, skidding costs per thousand board feet are expected to decrease, all other things being equal. Symbolically, the hypotheses tested are:

1. When we expected a variable to increase costs,

$H_o : \beta_i = 0$
$H_a : \beta_i > 0$

2. When we expected a variable to decrease costs,

$H_o : \beta_i = 0$
$H_a : \beta_i < 0$

3. When we did not know whether a variable would increase or decrease costs,

$H_o : \beta_i = 0$
$H_a : \beta_i \neq 0$

Hypotheses 1 and 2 were tested at $\alpha = 0.05$ (one-tail test); hypothesis 3 at $\alpha = 0.10$ (two-tail test). Although the statistical and mathematical procedures of regression analyses are relatively straightforward, the results (identifying significant explanatory variables and estimating coefficients) can be affected by the way in which the regression models are constructed and the computational procedures specified. If the objective was to predict appraisal costs, the regression analyses would be aimed at developing the most accurate prediction, using the fewest and simplest explanatory variables. As noted earlier, however, the objectives of this study were to analyze the effect of nontimber variables and to derive the best estimate of how these affect costs.

In this study we assumed the "best estimate" model to be one in which any of the variables that could potentially affect costs were tested for significance. The large

number of variables included in the study and a fairly large data base raise the possibility that regression analysis will produce spurious relationships—that is, mathematically and statistically significant, but illogical from the real-world standpoint. In building the models we tried to screen candidate variables to avoid this problem. These screened explanatory variables (site, decision, specific activities, and nontimber variables) were used in the analyses. Using standard stepwise regression procedures, the best estimate model computed the b coefficient and standard errors for each significant variable.

In typical multiple linear regression models, the question of range and variability of estimated coefficients is handled through confidence intervals computed from the standard error. This procedure was used in this study (Appendix A), but we also assessed the range of estimates by using different models that represent alternative approaches or philosophies to assessing the effects of nontimber variables on costs. These alternative approaches tend to make estimates of the cost of nontimber provisions (the b_i's) as large or as small as possible, thereby setting reasonable limits to the size of these costs. If two variables are totally independent of one another with regard to costs, then their estimated b coefficients will not change regardless of the analytical model used.

One point of view is that certain site characteristics are part of every sale and therefore their effects on cost should always be included first in the analysis. This approach was taken in one analysis by first "locking in" selected site variables and then allowing other variables to enter in a regular stepwise manner. Analytically, when this is done the variation explained by the site variables is first removed, and the nontimber variables can explain only the variation in cost that remains. We hypothesized that this would reduce the effect of nontimber concerns as measured by the estimated b coefficients, and we called it the "minimize nontimber" model.

An opposite point of view is that, regardless of site characteristics involved, the real concern is for the effects of nontimber considerations and that these costs can properly be measured only if the effects of site variables are removed from the analysis. This approach was taken in an analysis that excluded site variables from the model. This was termed the "maximize nontimber" model, because when site variables are excluded all variation in costs is attributed to the nontimber concerns and thus their estimated b coefficients would potentially be larger.

The above regressions were checked for violations of the assumptions that are the basis of the linear stochastic regression model. Examples of some of the assumptions that were checked are:

1. The variance of ϵ (error term) is constant
2. The error ϵ has a normal distribution
3. The explanatory variables are not perfectly linearly correlated
4. The assumption of linearity is true.

Plotting techniques and various "diagnostics" were used to validate the models. These techniques are explained in various texts (Koutsoyiannis 1979; Belsley and others 1980; Draper and Smith 1981).

In presenting the results in the next section, our discussion focuses primarily on the best estimate model, and the variables and their coefficients from the others—maximize or minimize nontimber—are discussed relative to the best estimate model.

RESULTS

In this section we present the results of the cost model regressions and discuss the variables that are significantly related to cost. The models are presented in more or less the chronological order of harvesting activities.

Table 1.—Felling and bucking cost model

Variable[1]	Unit	Best estimate		Minimize nontimber		Maximize nontimber	
		b coefficient (s.e.)					
Site							
LOGM	# logs	0.779	(0.051)	0.779	(0.051)	[2]	
Decision							
GPSEL	% area	-.066	(.029)	-.066	(.029)	—	
Special activity							
WHOT	0,1	-2.909	(1.215)	-2.909	(1.215)	—	
FELLO	% area	-.021	(.008)	-.021	(.008)	-0.022	(0.012)
ONTR	0,1	3.783	(1.166)	3.783	(1.166)	4.694	(1.761)
Nontimber							
SOACT3	0,1	2.326	(.946)	2.326	(.946)	2.744	(1.421)
VQO	0,1	—		—		2.191	(1.140)
Constant		9.826	(1.146)	9.826	(1.146)	22.378	(1.178)
R^2		.603		.603		.104	
s.e of model		4.967		4.967		7.456	

[1]See text for definition of variables.
[2]Indicates this variable forced out of this model.

Felling and Bucking Cost Model

The average appraised cost allowance for felling and bucking was $22.86/M bd ft and ranged from $12.59 to $59.14/M bd ft. The explanatory variables are summarized in table 1 and are listed in the following order: site, decision, specific activity, and nontimber resource.

SITE VARIABLE

Logs per M bd ft (LOGM).—Logs (16.4 ft) per M bd ft is recognized as an important cost determinant in many phases of logging. Its b coefficient was +0.779 in the best estimate model, indicating an increase of one log per thousand board feet "causes" an increase of about $0.78/M bd ft in felling and bucking costs. "Causes" is used in the logical sense that more logs require more labor, and so on; in a statistical sense the proper description is that the changes in both logs/M bd ft and costs are positively related.

HARVEST DECISION VARIABLE

Group selection (GPSEL).—In the best estimate model each 1 percent increase of group selection cutting in the sale area reduced felling and bucking costs about $0.06/M bd ft (b = −0.066). Group selection generally involves large, old-growth trees that have a large volume per stem, which reduces costs of felling and bucking. The coefficient was the same in the minimize nontimber model, and was not significant in the maximize nontimber model.

SPECIFIC ACTIVITIES VARIABLES

Whole-tree logging (WHOT).—When whole-tree logging was specified, costs were reduced by about $2.91/M bd ft (b = −2.909). In this method the sawyer only fells the tree and thus costs of limbing and bucking are eliminated from this phase. This may, of course, increase costs at the log landing or in slash disposal. The coefficient was the same in the minimize nontimber model; this requirement was not, however, significant in the maximize nontimber model.

Directional felling (FELLO).—Directional felling was measured in percentage of sale area in which it was required; it reduced costs by about $0.02/M bd ft for each 1 percent of area where it was required (b = −0.021 in best and minimize models). This is usually specified to facilitate yarding and to reduce damage to soil and residual trees. It apparently is also associated with slightly lower felling and bucking costs because it usually involves larger, old-growth trees whose additional volume offsets any increased labor involved.

Other nontimber requirements (ONTR).—Miscellaneous specific activities undertaken on the sale (ONTR) increased felling and bucking costs by about $3.78/M bd ft (b = 3.783) in the best and minimize models. When the site variable LOGM was forced out in the maximize nontimber model, the coefficient increased to 4.694. Miscellaneous other requirements were present on about 12 percent of the sales and included such things as special closures, installing sediment traps, use of flagpersons, and debris removal.

GENERAL NONTIMBER REQUIREMENTS (NTR'S)

Logging modified to protect soil (SOACT3).—When the timber sale plan modified logging activities to protect soil, the best estimate and minimize models predict that costs are increased by about $2.33/M bd ft (b = 2.326); the maximize model predicts $2.74 (b = 2.744). Usually soil protection measures involve yarding and roading activities, but there is apparently some secondary effect also on felling and bucking.

Visual quality objective (VQO).—If a visual quality objective had been specified for the sale, the maximize nontimber model predicts that felling and bucking costs would increase by about $2.19/M bd ft (b = 2.191); this was not significant in either the best estimate or minimize models. The reasons for this relationship are not identified, but it may reflect efforts to shape edges, reduce slash visibility, and so on; however, this variable was significant only in the maximize model that has forced out LOGM, the most important single cost factor.

DISCUSSION OF FELLING AND BUCKING COSTS

Table 1 reflects the similarity of the various alternative models for estimating the effect of different variables on felling and bucking costs. The best estimate and minimize nontimber models are identical. The maximize nontimber model has fewer explanatory variables, and these indicate a much larger effect of nontimber considerations. As stated previously, the objective was to estimate the maximum effect of nontimber considerations when all variations in cost were attributed to nontimber considerations.

"How much do nontimber considerations cost?" One answer is shown in figure 1. Recognizing that costs allowed for felling and bucking varied from $12/M bd ft to $59/M bd ft, this variability is explained primarily by site characteristics, in this case LOGM. The remaining

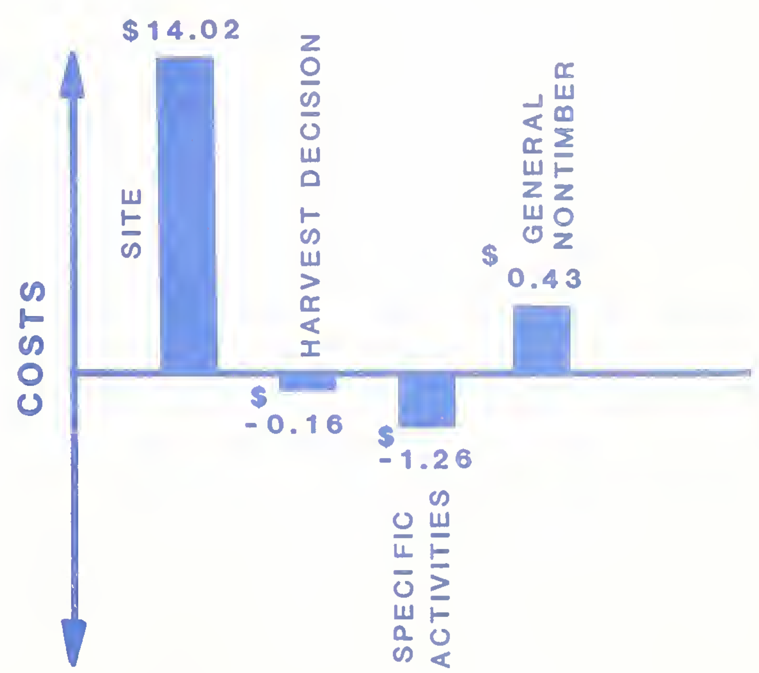

Figure 1.—Average contribution to felling and bucking costs by groups of variables, $/M bd ft.

variability is explained by requirements that directly or indirectly reflect nontimber considerations. This is based on the mean values—the average cost components of the sample sales. In the best estimate model, the constant ($9.83), plus the site variable LOGM, $14.02 (18 logs on average sale × 0.779 = 14.02) total $23.85/M bd ft. Because the average cost allowed was $22.86, this indicates that the net effect of all the other variables on the average sale is to slightly reduce felling and bucking costs. When the site variable LOGM is forced out in the maximize nontimber model and only nontimber-related variables remain, the net effect on the average sale is to add $0.48/M bd ft (average cost $22.86 minus the constant $22.38 = +$0.48). This suggests that usually nontimber considerations have little effect on felling and bucking costs.

Skidding and Loading Cost Model

The average appraised allowance cost for this item was $46.32/M bd ft, and ranged between $23.35 and $90/M bd ft. The variables that were significant in this model are summarized in table 2.

SITE VARIABLES

Logs per M bd ft (LOGM).—Costs increased by about $0.80/M bd ft for each additional LOGM in the best estimate model (b = 0.798). This is an expected relationship; increasing the number of pieces raises the costs of skidding and loading.

Volume per acre (VOL/A).—This variable in effect reduced costs by about $0.23/M bd ft (b = −0.230) for each increase of 1 M bd ft/acre. This reflects that less area has to be covered to skid a given volume of logs.

HARVEST DECISION VARIABLES

Skyline area (SKYA).—This variable indicated a $0.23/M bd ft increase in cost for each 1 percent increase in area skyline logged (b = 0.226). The coefficient was slightly higher in the minimize and maximize models, but these small differences are not statistically significant. This relationship is expected because skyline yarding is a relatively expensive yarding system.

Tractor log area (TLOGA).—The estimated effect of a 1 percent increase in tractor log area is a decrease of $0.15/M bd ft on cost (b = −0.153), again an expected effect because tractor logging is less expensive. This variable was not significant in the maximize model.

SPECIFIC ACTIVITIES VARIABLES

Corridor width (CORWID).—When corridor width is constrained (measured as present or absent), costs of skidding and loading are increased by $3.94/M bd ft (b = 3.941). Generally this requirement specified a corridor narrower than usual be used to protect residual leave-trees or understory; this variable was not significant in either the maximize or minimize models.

GENERAL NONTIMBER REQUIREMENTS (NTRS)

Soil plan (SOPLAN); logging modified to protect soil (SOACT3).—If the timber sale planning indicated consideration of soil protection, costs were increased by about $4.77/M bd ft (b = 4.771), and if logging activities were specifically modified to protect soil, skidding and loading costs are estimated to increase by another $3.47/M bd ft (b = 3.468). Making provisions for soil protection probably affects skidding more than any other phase, because factors such as road spacing, type of yarding, and restrictions on season of yarding are commonly used for soil protection and are directly related to off-road transportation costs. These two nontimber variables had slightly different coefficients in both the minimize and maximize models, but the differences were not significant.

Miscellaneous other wildlife (WLOTH).—The protection or enhancement of wildlife habitat other than food and cover (travel areas, calving grounds, wallows, and so

Table 2.—Skidding and loading cost model

Variable[1]	Unit	Best estimate		Minimize nontimber		Maximize nontimber	
		b coefficient (s.e.)					
Site							
LOGM	number	0.798	(0.097)	0.755	(0.097)	[2]	
VOL/A	M bd ft	−.230	(.079)	−.236	(.079)	[2]	
Decision							
TLOGA	% area	−.153	(.026)	−.142	(.026)	—	
SKYA	% area	.226	(.032)	.262	(.029)	0.279	(0.028)
Specific activity							
CORWID	0,1	3.941	(1.598)	—		—	
Nontimber							
SOPLAN	0,1	4.771	(1.870)	5.662	(1.862)	4.924	(2.128)
SOACT3	0,1	3.468	(1.577)	3.827	(1.594)	3.559	(1.919)
WLOTH	0,1	3.291	(1.514)	3.348	(1.537)	4.322	(1.813)
Constant		34.60	(3.107)	34.36	(3.152)	35.22	(2.092)
R^2		.609		.595		.399	
s.e. of model		8.04		8.15		9.89	

[1]See text for definition of variables.
[2]Indicates this variable forced out in this model.

on) was estimated to increase costs by \$3.29/M bd ft (b = 3.291). In these special areas, skidding requirements such as full suspension of logs or no entry with tractors (necessitating winching) would increase costs.

DISCUSSION OF SKIDDING AND LOADING COSTS

Skidding and loading costs ranged from \$23 to \$90/M bd ft. As with felling and bucking, LOGM was again an important site variable and, along with volume per acre, accounted for about \$10.68 of the average costs (fig. 2). Harvest decisions on type of logging method used, skyline or tractor, were also important. This was reflected by the general nontimber requirements (NTRS) SOPLAN and SOACT3, which accounted for \$5.48/M bd ft on the average. The specific activity variable CORWID also relates to protecting the site and added \$1.04/M bd ft on the average. Providing for nontimber resources therefore accounted for \$6.52 (\$5.48 +\$1.04)/M bd ft of the total skidding and loading cost of \$46.32/M bd ft.

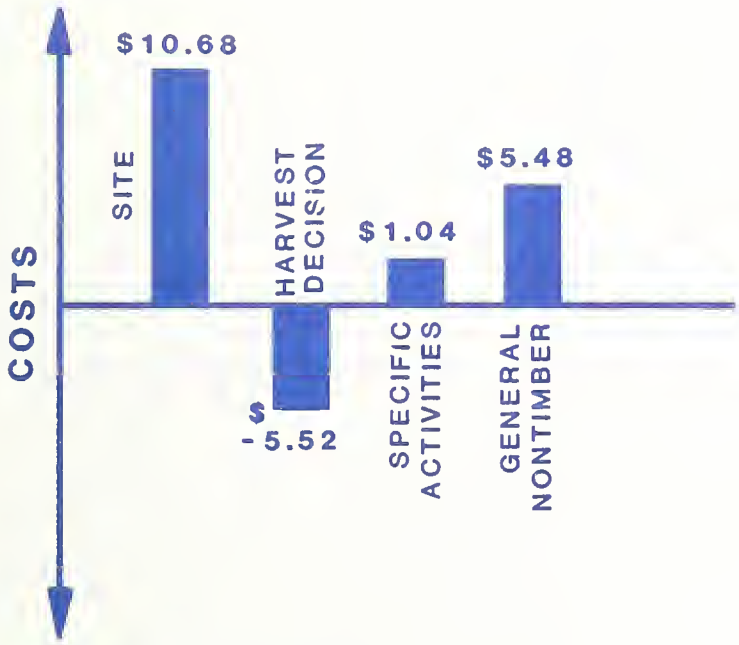

Figure 2.—Average contribution to skidding and loading costs by groups of variables, \$/M bd ft.

While analyzing the data, many other constraints and provisions were tested as candidate variables. Individually they did not constitute a pattern that was statistically significant, but the general nontimber variables SOPLAN, SOACT3, and WLOTH can probably be viewed as variables that may indirectly reflect the importance of other "nitty gritty" requirements that are more directly tied to skidding costs.

Hauling Cost Model

The average appraised cost for hauling was \$23.42/M bd ft and ranged between \$7.04 and \$58.99. Explanatory variables and their coefficients are shown in table 3.

SITE VARIABLES

Paved haul (PAVEHAUL) and unpaved haul (UNPAVEHAUL).—These two variables, which together represent hauling distance, were the most significant and, as might be expected, accounted for most of the variation in haul costs. Costs increased about \$0.38/M bd ft for each additional paved mile (b = 0.381) and \$0.50/M bd ft for each unpaved mile (b = 0.502).

Logs per M bd ft (LOGM).—Costs were increased by about \$0.23/M bd ft for each additional LOGM (b = 0.228). Smaller logs have less board-foot scale per unit of log weight, and this apparently is taken into account in haul costs.

SPECIFIC ACTIVITIES VARIABLES

Road grade (RDGRADE).—This variable indicated that costs increased by about \$0.80/M bd ft for each 1 percent

Table 3.—Hauling cost model

Variable[1]	Unit	Best estimate		Minimize nontimber		Maximize nontimber	
		b coefficient (s.e.)					
Site							
PAVEHAUL	mile	0.381	(0.024)	0.381	(0.024)	[2]	
UNPAVEHAUL	mile	.502	(.043)	.502	(.043)	[2]	
LOGM	number	.228	(.056)	.228	(.056)	[2]	
Specific activity							
RDGRADE	% slope	.805	(. 9)	.805	(.179)	0.984	(0.271)
RDWID	0,1	−2.429	(1.053)	−2.429	(1.053)	—	
Nontimber							
WLFOOD	0,1	1.519	(.864)	1.519	(.864)	2.270	(1.290)
WPD&E	0,1	1.697	(.983)	1.697	(.983)	—	
WLTRAVEL	0,1	—		—		7.376	(2.583)
SOPLAN	0,1	—		—		−4.140	(1.778)
CULPLAN	0,1	—		—		3.161	(1.335)
Constant		−4.938	(2.556)	−4.938	(2.556)	14.159	(2.985)
R^2		.647		.647		.164	
s.e. of model		5.36		5.36		8.20	

[1]See text for definition of variables.
[2]Indicates this variable forced out in this model.

increase in allowable road grade (b = 0.805). The average road grade specified was 9 percent—minimum 4 percent, maximum 15 percent—so the potential effect on any given sale is considerable. The estimated effect appears even higher (b = 0.984) when nontimber is maximized, but this is not significantly different from the best estimate.

Road width (RDWID).—The usual road width specified is bunk width plus 4 ft. If a different width was specified it usually resulted in wider roads, which in turn were estimated to reduce hauling costs by about $2.43/M bd ft (b = −2.429). This probably means that increasing road width may reflect other variables (not measured) that would contribute to lower haul costs, such as more favorable alignment, flatter terrain, and higher speed limits.

GENERAL NONTIMBER REQUIREMENTS (NTR'S)

Wildlife plan for deer and elk (WPD&E).—If a general plan for protecting wildlife was part of the timber sale plan, appraisal hauling costs were raised an estimated $1.70/M bd ft (b = 1.697). A wildlife plan includes many items that could affect hauling: layout of cutting units, location of roads, seasonal restrictions, closures, and others.

Wildlife food (WLFOOD).—If a specified objective in the sale was to protect or enhance wildlife food (mainly for deer and elk), appraisal hauling costs were further increased by about $1.52/M bd ft (b = 1.519). The reason for this is not clear, but wildlife concerns probably call for less direct routing, narrower roads, and road closures or other restrictions that could cumulatively lead to greater hauling costs.

Wildlife travel zones (WLTRAVEL), soil plan (SOPLAN), and cultural plan (CULPLAN).—These three general nontimber variables were not significant in the best estimate model but did enter as significant when the important site variables were excluded in the maximize nontimber model. Their importance should therefore be viewed with some reservations.

Protecting wildlife travel zones was estimated to increase hauling costs by $7.38/M bd ft (b = 7.376) in the maximize model. The reason is probably similar to that for providing wildlife food: concern for wildlife indicates various road-related constraints that restrict hauling. The data, however, did not clearly show how this variable was related to haul costs; therefore the relationship should be considered speculative.

Soil plan (SOPLAN) was also significant only in the maximize model and lowered haul cost by $4.14/M bd ft (b = −4.140) when soil protection was a consideration. This may indicate that raising road standards and maintenance to protect soils also reduces hauling costs.

If the sale included considerations for a cultural plan, hauling costs were estimated to be increased $3.16/M bd ft (b = 3.161). Cultural plans include a variety of concerns, both historical and current, and in the case of hauling would usually involve closures, safety measures, or similar requirements.

DISCUSSION OF HAULING COSTS

In examining the hauling costs (fig. 3), it is apparent that the site variables PAVEHAUL, UNPAVEHAUL, and LOGM account for much of the average costs (nearly $20). Two road structure-related specific activities variables, RDWID and RDGRADE, account for another $7. The road specifications probably reflect both soil/water considerations and other vehicle-related considerations like truck hauling speeds, recreation vehicle safety, and so on. At any rate, the two road-related variables account for about $6.95/M bd ft (average values of sample sale multiplied by the best estimate coefficients) and the two wildlife considerations another $1.82/M bd ft.

Figure 3.—Average contribution to haul costs by groups of variables, $/M bd ft.

Road Maintenance Cost Model

The average appraisal allowance for road maintenance was $5.48/M bd ft, and ranged between $0.15 and $31.37. The significant variables are presented in table 4.

SITE VARIABLES

Unpaved haul (UNPAVEHAUL).—Maintenance costs were increased by about $0.21/M bd ft for each mile of unpaved hauling (b = 0.206) in the best estimate model. Unpaved roads must be graded and cleared of debris, and ditches and culverts kept in working order. The effect was virtually the same in the minimize nontimber model.

Paved haul (PAVEHAUL) and logs per M bd ft (LOGM).—These two variables were forced into the minimize model for reasons cited earlier, but were not significant in the best estimate model. We hypothesized that more logs per thousand (LOGM) could affect allocation of transportation costs in the appraisal, but this variable

Table 4.—Road maintenance cost model

Variable[1]	Unit	Best estimate		Minimize nontimber		Maximize nontimber	
		b coefficient (s.e.)					
Site							
PAVEHAUL	mile	—		0.022	(0.019)	[2]	
UNPAVEHAUL	mile	0.206	(0.030)	.223	(.033)	[2]	
LOGM	number	—		.004	(.043)	[2]	
Specific activity							
SNOW	0,1	—		—		−1.505	(0.885)
CLOSBAR	number	—		—		.142	(.081)
ORA	0,1	1.573	(.806)	1.560	(.824)	2.779	(.876)
Nontimber							
CULPLAN	0,1	1.833	(.658)	1.850	(.675)	1.577	(.742)
VQO	0,1	1.291	(.620)	1.196	(.636)	—	
Constant		.634	(.708)	−.082	(1.318)	3.960	(.692)
R^2		.280		.278		.113	
s.e. of model		4.06		4.14		4.51	

[1]See text for definition of variables.
[2]Indicates this variable forced out of this model.

was significant only when forced in. The coefficient was <$0.01/M bd ft, which is not significantly different from 0. Maintenance costs increased about $0.02/M bd ft for each additional mile of paved haul (PAVEHAUL) but were not significant in the best estimate model.

SPECIFIC ACTIVITIES VARIABLES

Special road activities (ORA).—In some sales, special maintenance is required above and beyond the standard provisions; when present, these requirements (constraints on equipment, special vegetation treatment, and so on) added $1.57/M bd ft to appraised maintenance costs in the best estimate model (b = 1.573). In the maximize nontimber model this was increased to b = 2.780, which is notably higher.

Closure barriers (CLOSBAR) and snow removal required (SNOW).—We hypothesized that these requirements would affect maintenance costs, but they proved significant only in the maximize model. For each closure barrier, maintenance costs were estimated to increase $0.14/M bd ft (b = 0.142). This probably results from the cost of keeping barriers intact and possibly reflects the existence of conditions that are even more fragile and difficult to maintain (cleaning ditches, resurfacing), which leads to closures. In the maximize nontimber model, snow removal was a significant variable and was estimated to reduce maintenance costs by $1.50/M bd ft (b = −1.505). The reason for this is not clear, but to the extent that this indicates winter logging, hauling on frozen and snowpacked roads may result in less damage to road surfaces than spring or summer hauling and could reduce maintenance needs. This should be considered a speculative relationship.

GENERAL NONTIMBER REQUIREMENTS (NTR'S)

Cultural resources plan (CULPLAN).—If the sale accommodated cultural resource considerations, the effect was estimated to be an additional $1.83/M bd ft (b = 1.833). Because cultural concerns include both historical and current factors, this primarily reflects additional maintenance provided in the interest of people use (such as residences, popular recreation areas, and so on). The effect of this variable is less in the maximize model (b = 1.577), an unexpected result, but statistically the coefficients are not significantly different.

Visual quality objective (VQO).—If the sale area had specified a visual quality objective, the effect was to add $1.29/M bd ft (b = 1.291) to maintenance. Although this relationship was not specifically explained, it probably indicates that where visitor use activities are accommodated in a cultural plan, a visual quality objective has been incorporated.

DISCUSSION OF MAINTENANCE COSTS

The best estimate model indicates that the site variable UNPAVEHAUL accounts for most of the average costs (fig. 4), but general nontimber requirements are notably important. When the average UNPAVEHAUL effect (13.4 miles × 0.206 = $2.76) is added to the constant, +0.63, the apparent remaining effect of special maintenance requirements (presumably mostly for nontimber purposes) and of the nontimber considerations, cultural and visual concerns, is about $2.09/M bd ft (average maintenance, $5.48 −$2.76 − $0.63 = $2.09). Although the direct link between these nontimber considerations and maintenance allowance was not always defined, they consistently contribute to this cost.

Temporary Road Cost Model

Temporary roads were a relatively small cost item and are estimated separately from specified (required) roads. Temporary roads are considered a logging cost, not required or reimbursable. The average allowance was $1.03/M bd ft, ranging from 0 (no temporary roads needed) up to $15.02/M bd ft. The variables associated with temporary road costs are shown in table 5. For the most part they reflect the type of yarding system.

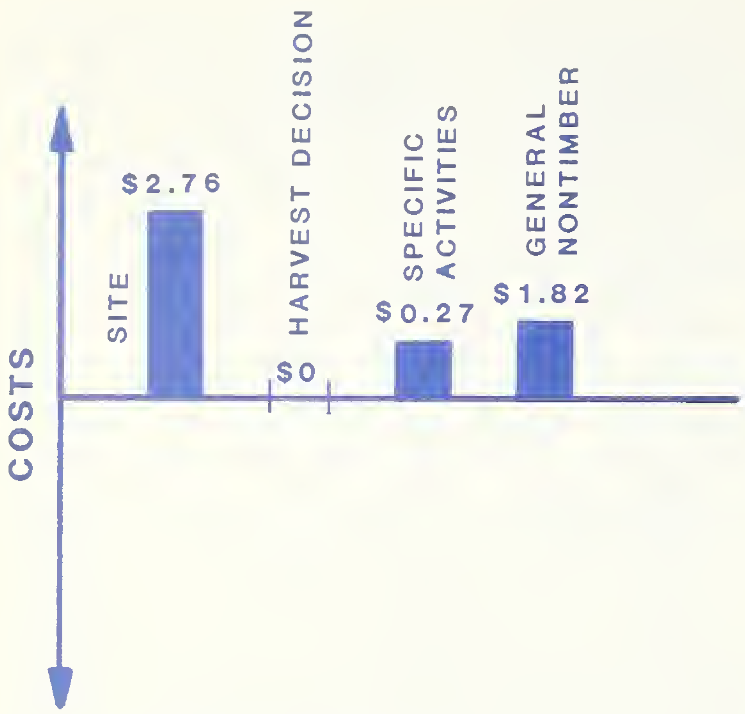

Figure 4.—Average contribution to road maintenance costs by groups of variables, $/M bd ft.

SITE VARIABLES

Road construction (CONST) and road reconstruction (RECON).—We hypothesized that permanent road construction and reconstruction might be related to temporary roads, but these variables were not significant in the best estimate model. When forced in the minimize model the variables were statistically insignificant and, as shown in table 5, they have virtually no effect on costs.

HARVEST DECISION VARIABLE

Mean acres in cutting units (MEANAC).—When mean size of the harvest unit increased by 1 acre, temporary road costs are estimated to increase by about 0.5 cent/M bd ft (b = 0.005). This is because larger units generally require more temporary roads for access, but the effect on costs is almost negligible.

SPECIFIC ACTIVITIES VARIABLES

Road spacing (SPACE).—When road spacing is restricted, costs for temporary roads increase by about $1.12/M bd ft (b = 1.124). This probably means that restrictions may preclude locating these temporary roads where construction is cheapest.

Skid slope grade (SKIDSLO).—As the slope (in percent grade) allowed for tractor logging increases, apparently fewer temporary roads are required; costs decreased by an estimated $0.03/M bd ft for each 1 percent slope (b = −0.033).

DISCUSSION OF TEMPORARY ROAD COSTS

Unlike other phases of logging, the net effect of the nontimber resource considerations on temporary roads appears to be to reduce costs. The constant (which represents an estimate of costs when all variables are at 0) is about $1.78/M bd ft and the mean cost of temporary roads is $1.10. Road spacing restrictions and size of cutting units at their mean values tend to slightly increase costs, but this is more than offset by the lower cost associated with skid slope. The relative importance of variables in explaining costs is shown in figure 5. In a statistical sense, the model was significant, but in a practical sense the cost of temporary roads was a small part of the total logging costs. Variables that should logically affect costs may have no real effect at all. There is some speculation, however, that current harvest practices use more temporary roads as a means to reduce the need for more expensive permanent roads. If this is the case, costs and variables may be different than the sales analyzed here.

Specified Road Cost Model

Roads to be constructed or reconstructed by the purchaser are often a major part of the sale cost. In the sample sales, the average was $32.52/M bd ft, and ranged from 0 (no construction required) to $112.45. The variables in the cost models are summarized in table 6.

Table 5.—Temporary road cost model

Variable[1]	Unit	Best estimate		Minimize nontimber		Maximize nontimber	
		b coefficient (s.e.)					
Site							
CONST	mile	—		0.0002	(0.015)[2]	[3]	
RECON	mile	—		−.0002	(.017)[2]	[3]	
Specific activity							
MEANAC	acre	0.005	(0.002)	.005	(.002)	0.005	(0.002)
SPACE	0.1	1.124	(.222)	1.126	(.222)	1.124	(.222)
SKIDSLO	% slope	−.033	(.012)	−.033	(.012)	−.033	(.012)
Constant		1.785	(.475)	1.783	(.488)	1.785	(.475)
R^2		.207		.208		.207	
s.e. of model		1.173		1.177		1.173	

[1]See text for definition of variables.
[2]Indicates this variable not significant in this model.
[3]Indicates this variable forced out of this model.

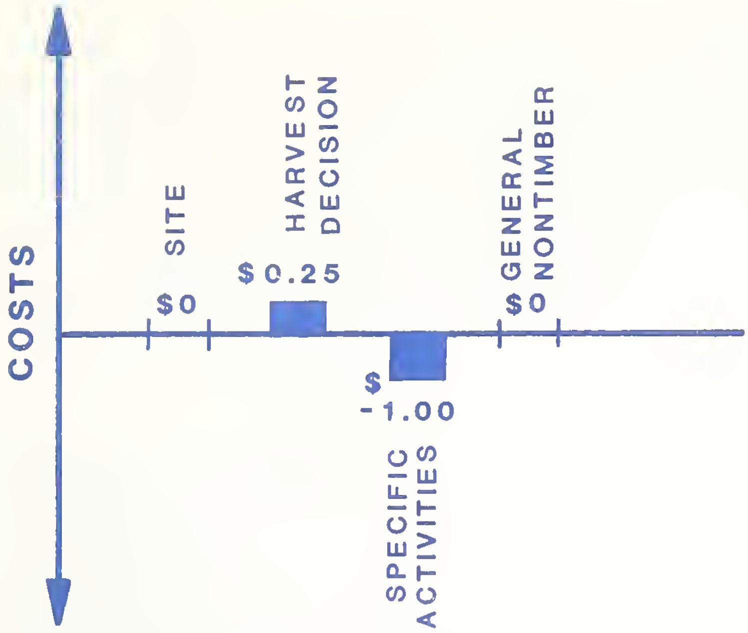

Figure 5.—Average contribution to temporary road costs by groups of variables, $/M bd ft.

SITE VARIABLES

Road construction (CONST).—As might be expected, the most important variable in this model was miles of specified road construction. Costs were predicted to increase by $2.29/M bd ft for each mile (b = 2.286) in the best estimate model.

Road reconstruction (RECON).—Road reconstruction specified in the sale was estimated to cost $0.69/M bd ft for each mile (b = 0.686) in the best estimate model.

HARVEST DECISION VARIABLES

Total acres harvested (TOTAC).—Total area in the sale was inversely related to road costs; that is, the larger a sale area, the lower the road costs per thousand board feet. As a rule, for a given amount of road construction, the more area harvested the more timber volume to bear the costs, and therefore the lower the costs per thousand board feet. In the best estimate model this was about $0.03/M bd ft lower per additional acre (b = −0.026).

Number of cutting units (NCU).—Other things being equal, the greater the dispersal of cutting units, the higher the road costs. This effect was estimated to be about $0.76/M bd ft in the maximize nontimber model (b = 0.756), but was not a significant variable in the other models.

SPECIFIC ACTIVITIES VARIABLES

Special cut and fill (CUTSEM).—If special cut and fill practices or seeding and mulching were required, costs were estimated to increase by about $8.41/M bd ft (b = 8.411) in the best estimate model, and slightly more in the minimize model. Only about 8 percent of the sales had such requirements so the average effect is small, but where these special measures are needed costs appear to be substantial. These include such measures as bin walls, terracing cuts, removing fill material, planting, and hydromulch. When the important site variables CONST and RECON are excluded, this variable has an estimated effect of about $14/M bd ft (b = 14.161).

Road spacing (SPACE).—If the minimum distance between roads was specified, costs were estimated to increase by more than $6/M bd ft (b = 6.521 in best estimate, and slightly higher in other models). The reason for this was not described, but wider spacing requirements are often in more difficult locations with less volume harvested per mile of road, which increases costs per thousand board feet.

Special road activities (ORA).—Miscellaneous other special road activities and requirements were present on about 17 percent of the sales, and, when required, were estimated to increase costs by over $6/M bd ft (b = 6.477 best estimate, and slightly higher in minimize model). This includes measures such as building sediment traps, maintaining vegetation, and time restrictions on road work. This was not, however, significant in the maximize nontimber model.

Table 6.—Specified road cost model

Variable[1]	Unit	Best estimate		Minimize nontimber		Maximize nontimber	
		b coefficient (s.e.)					
Site							
CONST	mile	2.286	(0.275)	2.186	(0.280)	[2]	
RECON	mile	.686	(.283)	.721	(.288)	[2]	
Decision							
TOTAC	acre	−.026	(.005)	−.023	(.005)	−0.012	(0.005)
NCU	number	—		—		.756	(.175)
Specific activity							
CUTSEM	0,1	8.411	(5.166)	8.240	(5.286)	14.161	(5.610)
SPACE	0,1	6.521	(3.539)	—		6.682	(3.963)
ORA	0,1	6.477	(3.912)	7.579	(3.938)	—	
Constant		25.209	(2.877)	25.930	(2.888)	25.990	(3.382)
R^2		.340		.308		.136	
s.e. of model		18.18		18.60		20.669	

[1]See text for definition of variables.
[2]Indicates this variable forced out of this model.

DISCUSSION OF SPECIFIED ROAD COSTS

Specified roads are, on the average sale, a fairly large-cost item. The most obvious site variables—construction, reconstruction, and total area—account for a considerable portion of the average cost (fig. 6). Special activities (road spacing, cut and fill, and other road requirements) on the average add about $3.20/M bd ft.

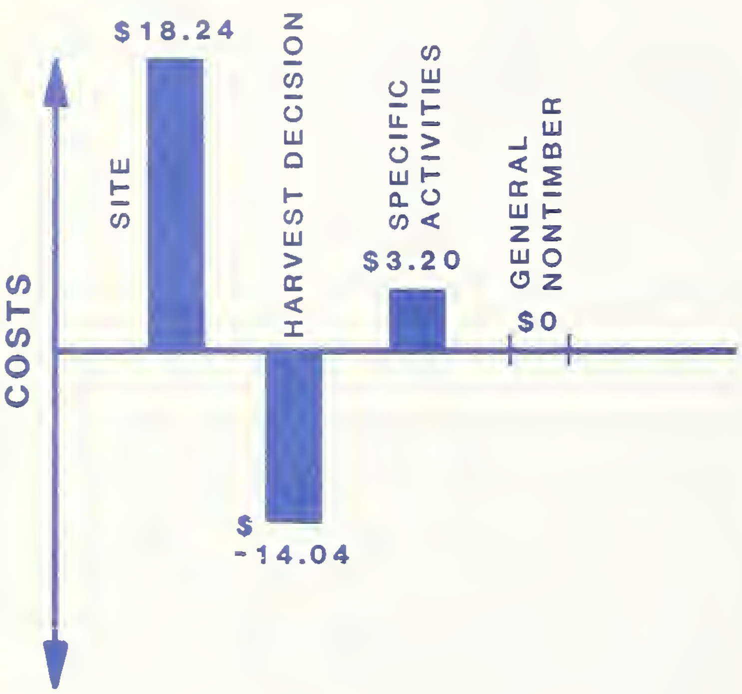

Figure 6.—Average contribution to specified road costs by groups of variables, $/M bd ft.

Slash Disposal Cost Model

Slash disposal costs ranged between $0.95 and $41.60/M bd ft, and averaged $12.40. This includes both allowance for work done by the contractor, and money collected from the purchaser for the Forest Service share of the work (usually burning). The variables associated with slash costs are presented in table 7. Most of the variables are directly related to the harvesting operation, but wildlife and soil-related considerations were also significant.

SITE VARIABLE

Volume per acre (VOL/A).—When volume increased by 1 M bd ft/acre, slash costs were estimated to be reduced by about $0.26/M bd ft (b = −0.265). Slash treatment to some extent is related to area covered, and the more volume, the less the slash disposal costs per unit of volume.

HARVEST DECISION VARIABLES

Mean acres in cutting unit (MEANAC).—The larger the size of the individual unit, the lower the slash cost, mainly because overhead costs of supervisory personnel and perimeter fireline are reduced as cutting unit size increases. The decrease was about $0.04/M bd ft (b = −0.038) for each acre increase in size.

Partial cut (PARTCUT).—Partial cutting harvest methods (shelterwood, individual tree mark, and commercial thinning) increase slash costs because both piling and burning operations require greater care to protect the residual leave trees. The best estimate model shows an increase of about $0.03/M bd ft for each 1 percent increase in the harvest area that is partial cut (b = 0.034); in the maximize model the increase is more than $0.05/M bd ft (b = 0.054).

Table 7.—Slash disposal cost model

Variable[1]	Unit	Best estimate		Minimize nontimber		Maximize nontimber	
		b coefficient (s.e.)					
Site							
VOL/A	M bd ft	−0.265	(0.065)	−0.265	(0.065)	[2]	
Decision							
MEANAC	acre	−.038	(.012)	−.038	(.012)	−0.029	(0.012)
TLOGA	% area	−.050	(.015)	−.050	(.015)	−.035	(.016)
PARTCUT	% area	.034	(.016)	.034	(.016)	.054	(.016)
Specific activity							
SPACE	0.1	3.100	(1.202)	3.100	(1.202)	3.135	(1.258)
Nontimber							
WPD&E	0.1	−2.940	(1.164)	−2.940	(1.164)	−2.837	(1.217)
SOACT3	0.1	2.210	(1.215)	2.210	(1.215)	2.419	(1.271)
Constant		20.93	(2.416)	20.93	(2.416)	13.863	(1.743)
R^2		.246		.246		.175	
s.e. of model		6.30		6.30		6.59	

[1]See text for definition of variables.
[2]Indicates this variable forced out of this model.

Tractor log area (TLOGA).—Tractor skidding reduces slash costs because usually tractor piling of slash is the least costly treatment; about $0.05/M bd ft less for each 1 percent of area tractor logged (b = −0.050 in best estimate, −0.035 in maximize model).

SPECIFIC ACTIVITIES VARIABLE

Road spacing (SPACE).—This restriction was estimated to increase slash costs over $3/M bd ft (b = 3.100 in the best estimate, and 3.135 in the maximize). This reflects in general the greater costs of treating slash long distances from roads.

GENERAL NONTIMBER REQUIREMENTS (NTR'S)

Wildlife plan for deer and elk (WPD&E).—When deer and elk management are part of the plan, slash costs are estimated to be reduced by about $2.94/M bd ft (b = −2.940). This was not explained in the data, but it may result from lighter slash loadings due to lighter cutting in areas being managed for deer and elk.

Logging modified to protect soil (SOACT3).—Soil protection activities add an estimated $2.21/M bd ft (b = 2.210 best estimate, 2.419 in maximize model). This primarily reflects situations where tractors (low-cost method) cannot be used for slash treatment because of concerns for soil disturbance or compaction.

DISCUSSION OF SLASH DISPOSAL COSTS

The average costs explained by this model are shown in figure 7. The specific activities and general nontimber considerations appear to have a rather important role in explaining cost variations. It should be noted, however, that specific activities add $0.64 and nontimber requirements reduce costs $1.87, so that on the average their net effect is to reduce cost $1.23/M bd ft. Considering the purpose of analyzing specific variables, however, the model appears to be highly informative; the variables have a generally consistent (across models) and logical relationship to costs.

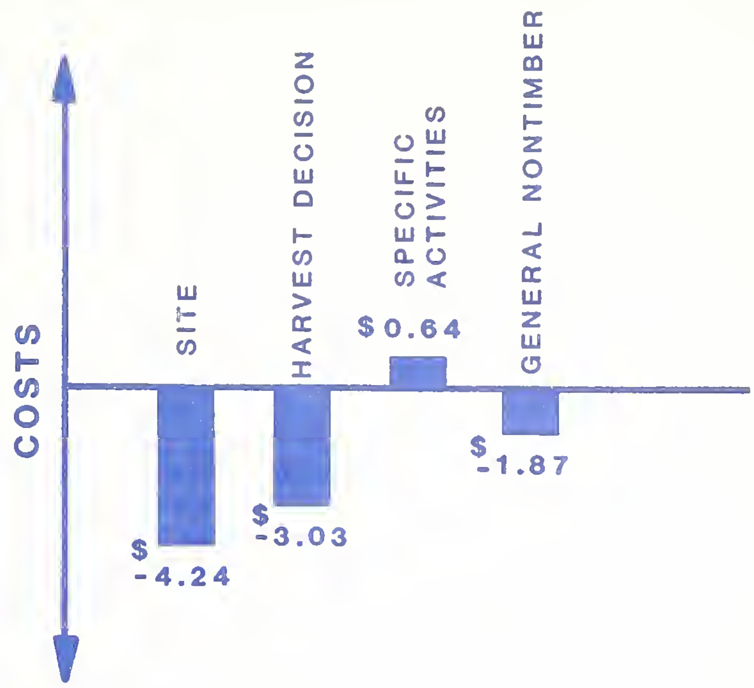

Figure 7.—Average contribution to slash costs by groups of variables, $/M bd ft.

Discussion of Cost Models

The models discussed above indicate that a considerable number of variables were significant in explaining the cost allowance for various phases of logging. Tables 8 through 11 show the costs identified above as expressed in terms of the average sale; that is, the mean values of variables times the best estimate coefficients from tables 1—7. In table 8, the average costs of site variables—those that are essentially fixed or given for a sale—are summarized for each site variable in each logging cost item. For example, the mean value of 13.4 miles of unpaved haul road is multiplied by the UNPAVEHAUL coefficients in the hauling and maintenance models to derive a total effect of +$9.49/M bd ft. The meaning of this can be illustrated by envisioning that a sale that had no unpaved haul miles would have no costs for this item; a 1-mile haul would be 0.502 (haul cost coefficient) + 0.206 (maintenance coefficient) × 1 mile = $0.71/M bd ft. Note that for VOL/A the effect is negative; that is if volume per acre were very low there would theoretically be some high costs for skidding and slash because cost of tractor would be distributed over only a few thousand board feet. But as volume increases up to the sample sale average of 16 M bd ft/acre, skid costs are reduced by $3.68/M bd ft and slash by $4.24/M bd ft, for a total effect of −$7.92/M bd ft.

Table 8.—Estimated average direct logging costs per thousand board feet associated with timber sale site characteristics best estimate model, 1980 dollars

Variable[1]	$\bar{X}$	Logging phase: Fell and buck	Skid and load	Haul	Maintenance	Temporary road	Specified road	Slash	Sum
		$/M bd ft							
LOGM	18/M bd ft	14.02	14.36	4.10					32.48
VOL/A	16 M bd ft/acre		−3.68					−4.24	−7.92
CONST	6.3 mi						14.40		14.40
RECON	5.6 mi						3.84		3.84
PAVEHAUL	23 mi			8.76					8.76
UNPAVEHAUL	13.4 mi			6.73	2.76				9.49
Total		14.02	10.68	19.59	2.76	0	18.24	−4.24	61.05

[1]See text for definition of variables.

These effects are illustrated in figure 8. The total portion of the average logging cost explained by these site variables is $61.05/M bd ft.

Recalling that the total logging cost averaged $144/M bd ft, the site and decision variables together have explained about $38.55/M bd ft. The next question, then, and the one that is the focus of the study, is: "How much of the remaining $105.45/M bd ft ($144 − $38.55) is explained by specific activities and general considerations made for nontimber concerns?"

In table 9, the decision variables are summarized. Note that although some variables **add** to costs (skyline area and partial cut area), others **decrease** costs (tractor logging area and total sale area). The net effect of these decision variables at the mean is to decrease costs by $22.50/M bd ft. What this means is that given the conditions expressed by site variables at their mean, and then applying the six decision variables at their mean values, the effect would be $61.05 − $22.50 = $38.55/M bd ft.

In table 10, the effect of specific activity variables at the mean is summarized. These values are computed exactly the same as was explained for site variables in

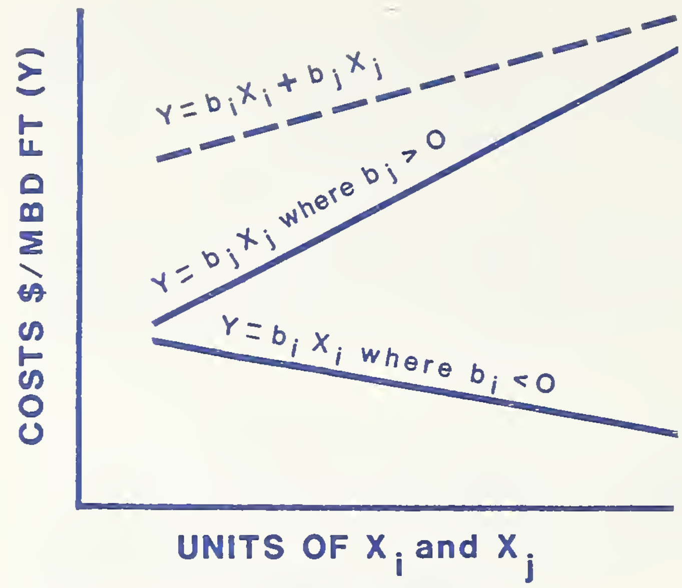

Figure 8.—Effect of continuous variables X_i and X_j on cost estimates.

Table 9.—Estimated average direct logging costs per thousand board feet associated with harvest decision variables best estimate model, 1980 dollars

Variable[1]	$\bar{X}$	Fell and buck	Skid and load	Haul	Maintenance	Temporary road	Specified road	Slash	Sum
		$/M bd ft							
TLOGA	62.87% of area		−9.62					−3.14	−12.76
SKYA	18.14% of area		4.10						4.10
MEANAC	50 acres/unit					0.25		−1.90	−1.65
TOTAC	540.5 acres harvested						−14.04		−14.04
PARTCUT	59% of area							2.01	2.01
GPSEL	2.4% of area	−0.16							−.16
Total		−0.16	−5.52	0	0	0.25	−14.04	−3.03	−22.50

[1]See text for definition of variables.

Table 10.—Estimated direct logging costs per thousand board feet associated with specific activities required for nontimber purposes, best estimate model, 1980 dollars

Variable[1]	$\bar{X}$	Fell and buck	Skid and load	Haul	Maintenance	Temporary road	Specified road	Slash	Sum
		$/M bd ft							
WHOT	0.102 of sales	−0.30							−0.30
FELLO	67.4% of area	−1.41							−1.41
ONTR	0.118 of sales	.45							.45
CORWID	0.278 of sales		1.04						1.04
RDGRADE	9.14% grade			7.36					7.36
RDWID	0.171 of sales			−.41					−.41
ORA	0.171 of sales				0.27		1.11		1.38
SKIDSLO	37.5% slope					−1.23			−1.23
SPACE	0.206 of sales					.23	1.34	0.64	2.21
CUTSEM	0.089 of sales						.75		.75
Total		−1.26	1.04	6.95	0.27	−1.00	3.20	0.64	9.84

[1]See text for definition of variables.

table 8 (b coefficient × mean value of variable). One additional feature, however, should be noted. Many of these variables are measured only as present or absent; as explained earlier, on a given sale they either have an effect equal to their coefficient if they are present, or no effect if they are absent. These effects are portrayed in figure 9. Our analysis, however, is built around a sample of 187 sales, so the sum of all the 0's and 1's divided by the 187 sales gives the mean values for these variables; it is the equivalent of the proportion of sales that have the variable present multiplied by the coefficients from tables 1—7 to give the average dollar effects shown in table 10. The total effect of all these specific activities on logging cost appraisals is +$9.84/M bd ft.

In table 11, the effects of the general nontimber requirements (NTR's) are summarized. As previously mentioned, these variables describe purpose, type, and objectives in general terms and all are 1,0 (present or absent) variables. Their average effects are computed as described above: total effect of all NTR's on logging costs is estimated to be $7.68/M bd ft. These effects on logging costs are summarized by phase and type of variable in table 12.

In table 13, the "bottom line" of each of the tables is summarized, and the values computed from the minimize and maximize models are included for comparison. The portion of the $144/M bd ft logging cost explained by the models varies from $27 to $57. Of note is that the variables we are primarily interested in—general nontimber and specific activities—are very similar in all models, totaling from about $16 to $18/M bd ft.

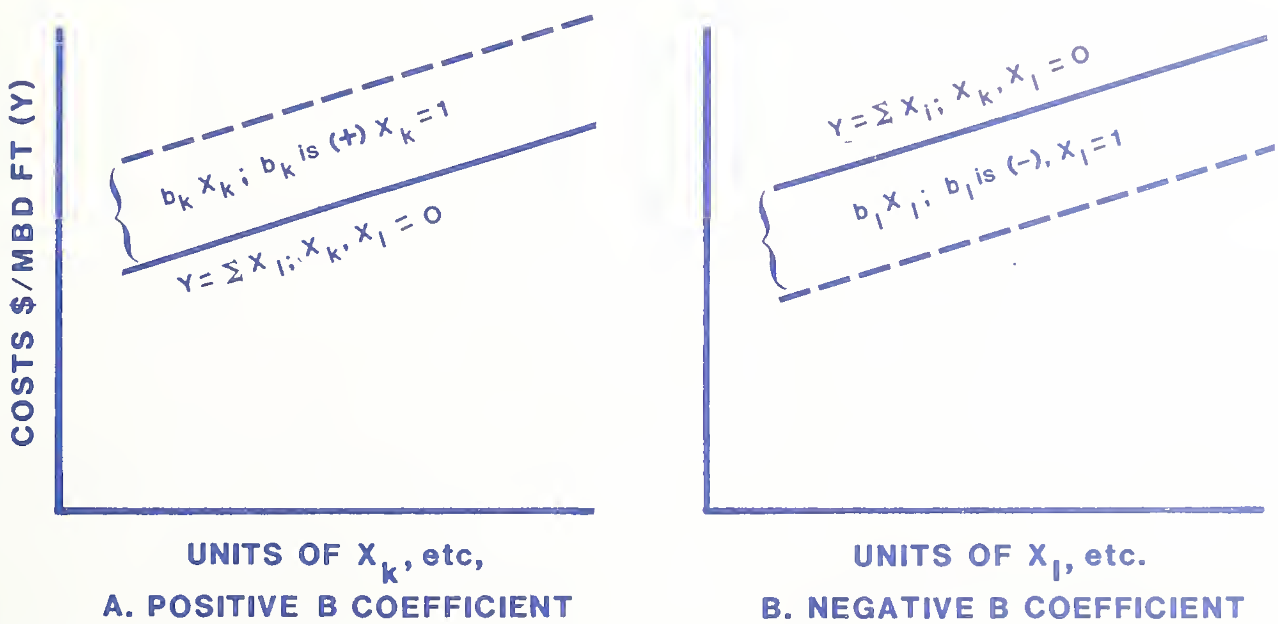

Figure 9.—Effect of present/absent (I,0) variables on cost estimates.

Table 11.—Estimated direct logging costs/M bd ft associated with general nontimber requirements (NTR's) best estimate model, 1980 dollars

Variable[1]	$\bar{X}$	Logging phase: Fell and buck	Skid and load	Haul	Maintenance	Temporary road	Specified road	Slash	Sum
		$/M bd ft							
SOPLAN	0.866 of sales		4.13						4.13
SOACT3	0.187 of sales	0.43	.65					0.41	1.49
WPD&E	0.775 of sales			1.31				−2.28	−.97
WLFOOD	0.337 of sales			.51					.51
WLOTH	0.214 of sales		.70						.70
CULPLAN	0.695 of sales				1.27				1.27
VQO	0.428 of sales				.55				.55
Total		0.43	5.48	1.82	1.82	0	0	−1.87	7.68

[1]See text for definition of variables.

Table 12.—Effect on average logging costs, by phase and type of variable, 1980 dollars

Phase	Site	Decision	Specific activity	Nontimber requirements
	$/M bd ft[1]			
Felling and bucking	14.02	−0.16	−1.26	0.43
Skidding and loading	10.68	−5.52	1.04	5.48
Haul	19.59	0	6.95	1.82
Road maintenance	2.76	0	.27	1.82
Temporary roads	0	.25	−1.00	0
Specified roads	18.24	−14.04	3.20	0
Slash	−4.24	−3.03	.64	−1.87
Total, logging	61.05	−22.50	9.84	7.68

[1]Derived by multiplying b coefficients, tables 1−7, by $\bar{X}$ for each variable.

Table 13.—Estimated average direct logging costs associated with various sale characteristics, 1980 dollars

Characteristic	Best estimate	Minimize nontimber	Maximize nontimber
	$/M bd ft		
Site characteristics	61.05	60.45	0
Harvest decision variables	−22.50	−19.55	9.94
Specific activities	9.84	7.63	10.78
General nontimber requirements	7.68	8.40	6.44
Total	56.07	57.03	27.16

Given that the estimated costs of nontimber-related considerations in planning and conducting sales are moderately small, the question remains just how much error is involved in these estimates. As indicated by the standard errors in tables 1—7, there is considerable variation in the b coefficients; for most variables, this error around the estimated mean coefficient is greater than the difference between coefficients in the three analyses. From a practical standpoint, this means the normal variation in costs estimated by the best estimate model is of more importance than alternate estimates by the minimize or maximize models. For example, in the best estimate model, the specific activities and general nontimber requirements total $17.52/M bd ft; in the minimize model they are slightly less, $16.13.

Bid Difference Model

Up to this point, the analysis of the effect of nontimber concerns has been from the viewpoint of the seller, the Forest Service. When the logging costs have been totaled and allowance made for manufacturing and other related costs, total costs are subtracted from the estimated value of the manufactured product to derive the indicated stumpage value. This is an estimate of what a purchaser of average efficiency would be willing to pay for the stumpage. Whatever the purchaser bids in excess of stumpage value is called the bid difference. In the sample sales the bid difference averaged $67/M bd ft.

The objective of this part of the analysis is to answer the question: "Do the nontimber requirements on a timber sale affect the purchaser's bid?" If the purchaser feels that some part of the logging appraisal has not allowed enough to cover his costs, he may reduce his bid. Conversely, if he feels he can meet requirements for less than the estimated cost, he may increase his bid.

The analysis of bid difference is summarized in table 14. Again, the three alternative models—best estimate, minimize nontimber, and maximize nontimber—were used to try to establish a range of estimates for the variables.

The individual variables are discussed in detail below. Conceptually, the effect of these variables on bid difference is additive to their effect on cost allowance; that is, if a bidder feels the appraisal either overallows or underallows for costs of some logging condition or requirement, he could conceivably increase or decrease his bid margin accordingly. Again, the discussion relates to the best estimate model but notes if there are any major differences in the other models.

SITE VARIABLES

Logs per M bd ft (LOGM).—Bid margin was increased $1.66/M bd ft (b = 1.665) for each additional log per thousand board feet in the best estimate model (b = 1.809 in minimize). In general, more LOGM would be expected to increase costs, but as noted, the bid difference may not reflect net costs, per se, but rather the bidder's judgment of logging cost estimate. Results suggest that purchasers felt they could do better than logging costs related to LOGM.

Volume/acre (VOL/A).—Volume per acre was not significant in the best estimate model, but when forced into

Table 14.—Bid difference model

Variable[1]	Unit	Best estimate		Minimize nontimber		Maximize nontimber	
		b coefficient (s.e.)					
Site							
LOGM	number	1.665	(0.474)	1.809	(0.496)	[2]	
VOL/A	M bd ft	—		.619	(.468)[3]	[2]	
CONST	mile	—		−.727	(.578)[3]	[2]	
RECON	mile	1.113	(.621)	1.357	(.630)	[2]	
PAVEHAUL	mile	.812	(.186)	.716	(.204)	[2]	
UNPAVEHAUL	mile	—		−.370	(.366)[3]	[2]	
Decision							
SKYA	% area	—		—		−0.429	(0.141)
MEANAC	acre	−.190	(.186)	−.180	(.080)	−.170	(.082)
Specific activity							
RDWID	0,1	−29.089	(8.969)	−28.330	(8.930)	−30.360	(9.480)
SPACE	0,1	−16.663	(8.347)	−15.973	(8.255)	−18.848	(8.848)
Constant		28.653	(11.648)	25.437	(17.140)	91.712	6.278)
R^2		.258		.273		.154	
s.e. of model		43.60		43.23		46.27	

[1]See text for definition of variables.
[2]These variables forced out of this model.
[3]These variables not significant at $\alpha = 0.05$.

the minimize model, bid difference increased about \$0.62/M bd ft (b = 0.619) for each additional thousand board feet per acre. This suggests that even when volume per acre increased and the costs allowed for logging decreased (from earlier models) bidders still increased their bid margin.

Construction (CONST).—Road construction also was not significant in the best estimate model, and was also not statistically significant when forced into the minimize model. The indicated effect was to reduce bid difference by \$0.73/M bd ft (b = −0.727) per mile of construction. This suggests road construction has a negative effect, but we can only speculate that it may be related to cost allowance made for roads or some other reason.

Reconstruction (RECON).—Miles of road reconstruction was significant in both best estimate and minimize models, with positive coefficients of b = 1.113 and 1.357, respectively. This suggests that purchasers increased their bid by \$1.11 to \$1.36/M bd ft for each mile of reconstruction. Two plausible reasons are that the appraised allowance was greater than the purchaser's actual costs; or that reconstruction is involved in areas already developed for timber and these have more favorable logging conditions—less remote, better timber, and so on—than previously unroaded areas.

Paved haul (PAVEHAUL).—Paved haul miles was significant in both the best estimate and minimize models, and indicated bid difference increased by about \$0.72/M bd ft (b = 0.716, minimize) to \$0.81 (b = 0.812, best estimate) per thousand board feet per mile. Again, apparently the purchasers saw a cost advantage over and above the cost allowance made for hauling on paved roads.

Unpaved haul (UNPAVEHAUL).—Unpaved hauling distance was not significant in the best estimate model and was not statistically significant when forced into the minimize model. The indicated bid decrease, however, was \$0.37/M bd ft (b = −0.370). This suggests that the purchaser thought total cost of unpaved haul miles was greater than that allowed for in the appraisal.

HARVEST DECISION VARIABLES

Skyline area (SKYA).—This variable was significant only in the maximize nontimber model, and indicated bid difference was decreased by about \$0.43/M bd ft (b = −0.429) for each 1 percent increase in SKYA. This is consistent with the general idea that skyline yarding is considered costly and more unpredictable than other methods of yarding and purchasers accordingly reduce their bids.

Mean acres in cutting unit (MEANAC).—This variable was significant in all three models and indicated bid margin is reduced by \$0.19/M bd ft for each additional acre (b = −0.190 in best estimate). This reverses the notion that increased size of a cutting unit brings some economies of scale to logging. There are, however, some reasons why larger units reduce bids. First, because clearcutting (usually the least costly method) is restricted to smaller units, large units indicate some type of partial cutting. Second, if road density is restricted, yarding distance is longer on large units. Finally, sales often have restrictions that require the completion of one unit before beginning another, and on large units the purchaser may feel this restricts his flexibility.

SPECIFIC ACTIVITIES VARIABLES

Road spacing (SPACE).—This variable, significant in all three models, indicated that when road spacing on the sale was restricted, bid difference was reduced by \$15.97 to \$18.85/M bd ft. This is generally consistent with the idea that wider road spacing increases yarding costs.

Road width (RDWID).—This variable was significant in all three models and indicated that when special road widths were specified, bid difference decreased by $28.33 to $30.36/M bd ft. This result suggests that abnormally wide or narrow roads are unusually costly to construct and that costs allowed for such roads are less than the purchaser's estimates.

COMMENTS ON BID DIFFERENCE MODEL

The bid difference model attempts to explain variations in bid difference—bid minus indicated stumpage value—in terms of variables that were significant in explaining logging cost appraisal allowances. Factors such as market expectations and competitiveness among stumpage buyers may also affect bidding. Even if consideration is limited to logging operations, bid differences may reflect advantages or disadvantages unique to a given buyer bidding on a sale. Jackson (1983) discusses how logging, manufacturing, and other considerations may affect stumpage appraisals and bidding. These considerations were not included in the bid models (many of them could not even be quantified). The bid difference models, however, appear to provide at least a general picture of how harvesting conditions and requirements may affect bid margins (fig. 10). Even without some of the important factors of bidding behavior, the analysis appears to yield plausible and stable estimates of the effects of nontimber considerations. Most coefficients did not differ appreciably among the three models.

When the dollar effect of these variables is computed (mean value of variable × b coefficient), the portion of bid difference "explained" by the best estimate model is:

LOGM	29.97
RECON	6.23
PAVEHAUL	18.67
Total, site variables	54.87
MEANAC	−9.48
Total, harvest decision	−9.48
RDWID	−4.97
SPACE	−3.43
Total, specific activities	−8.40

Because a positive bid difference is, in effect, a return to the seller (more received than what the timber was

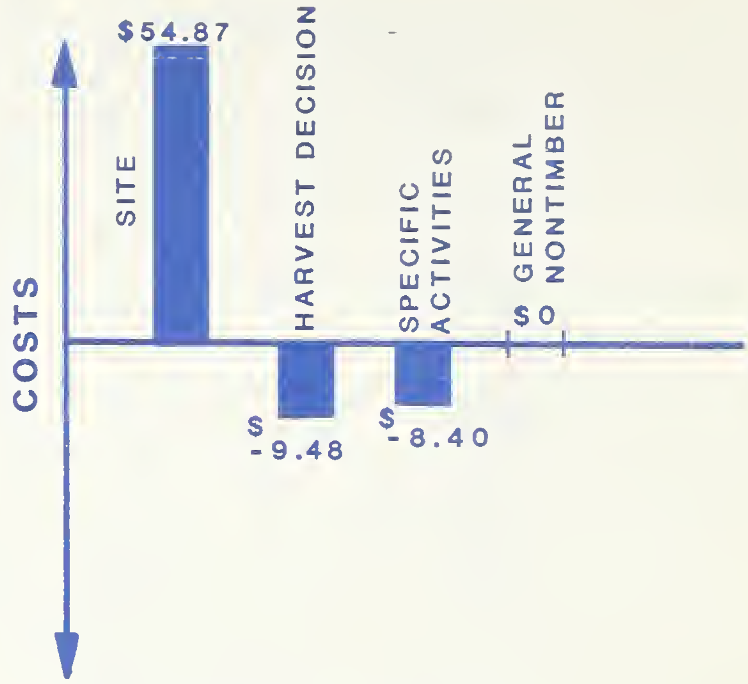

Figure 10.—Average contribution to bid difference by groups of variables. $/M bd ft

appraised to be worth), this model says that the site characteristics have benefited the seller. Conversely, because the specific activity variables RDWID and SPACE have decreased the bid margin, their effect is a cost to the seller. Therefore, the "cost" effects of these variables in the bid difference can be added to the costs of nontimber considerations determined in the logging cost models to derive the estimated total effect on stumpage values.

Total Effect of Nontimber Considerations on Stumpage Values

The analyses of logging costs and bid difference in the preceding sections have developed estimates of how various nontimber considerations affect appraised costs and bid difference, and using the mean values of the nontimber variables, have developed estimates of average costs. Table 15 shows the total effect of these costs; namely, combined effect on stumpage values. For example, for the best estimate models the specific activity variables

Table 15.—Total effect of general nontimber requirements and specific activities costs for logging phases and bid difference

Phase	Best estimate	Minimum	Maximum
		$/M bd ft	
Felling and bucking	−0.83	−0.83	0.51
Skidding and loading	6.52	6.33	5.84
Haul	8.77	8.77	8.80
Road maintenance	2.09	2.06	1.53
Temporary roads	−1.00	−1.00	−1.00
Specified roads	3.20	2.03	2.64
Slash	−1.23	−1.23	−1.10
Subtotal, logging	17.52	16.13	17.22
Bid difference	8.40	8.13	9.07
Total	25.92	24.26	26.29

and general nontimber requirements were estimated to "cost" $17.52/M bd ft. When the effect of specific activities from the bid difference analysis, $8.40/M bd ft, is added (because the reduction in bid is the same as an increase in costs), the resulting total is $25.92/M bd ft. Forest Service stumpage receipts were reduced by this amount to meet nontimber considerations on the 187 sales studied. Estimated totals for the minimize and maximize models are also shown in table 15. The range of these estimates, $24.26 to $26.29/M bd ft, indicates little difference in the "bottom line," even though quite different assumptions underlie the estimates. The 95 percent confidence interval around these means is discussed in appendix A.

SUMMARY AND DISCUSSION

Timber sales conducted on seven National Forests in northern Idaho and western Montana during 1975-80 (N = 187 sales) were analyzed to determine (1) if provisions to protect or enhance nontimber resources affected appraisal allowance for logging costs, and (2) if these provisions affected the amount purchasers bid for the timber.

For purposes of analyses, appraisal costs were divided into seven items (logging phases) and a regression analysis made for each. In these regression analyses, three approaches (models) were used to establish a range of estimated nontimber costs. The best estimate model used the conventional stepwise regression approach of adding explanatory variables to the model in order of their significance. Variables included characteristics of the timber sale site, harvest methods, and both general and specific nontimber requirements. An alternative analysis estimated how small the effect of nontimber considerations would be if the effects of selected site variables were arbitrarily included (this minimized nontimber costs). A third analysis maximized the effect of nontimber considerations by arbitrarily excluding site variables: this gave an estimate of how large nontimber costs might be.

The principal findings on how appraisal costs were related to nontimber considerations were:

- Most of the explanation of appraised costs is associated with site variables such as volume per acre and haul distance, or with decisions such as harvesting method and logging technique. Several variables reflecting general nontimber considerations and specific activities were statistically significant in each of the seven logging cost models.
- The net effect of nontimber concerns on the average sale (at the mean value of all variables) was to increase total appraised logging costs (sum of seven items analyzed) by about $17.52/M bd ft (best estimate).
- Of eight nontimber resources considered in the analysis, soil and wildlife appeared to have the biggest effect on costs. Cultural concerns and visual quality considerations were also statistically significant in some cost items but had less dollar effect. Among various specific activities undertaken for nontimber concerns, road-related activities were the most significant, and logging-related activities, especially felling and yarding, were the next most important.

The appraisal cost analyses estimate how much the Forest Service allows for nontimber concerns when setting stumpage value. An additional cost is the effect of nontimber considerations on the purchaser's bid difference; that is, the margin of his bid over the seller's (Forest Service) estimated value of the stumpage. This bid difference was also analyzed using the three types of models to estimate the range of effects. In this analysis, several nontimber considerations were statistically significant, and their net effect on bid difference was to reduce the bid margin by about $8.40/M bd ft (best estimate model).

When these two components are combined, the net effect of nontimber concerns is about $26/M bd ft:

Cost effect on logging cost appraisal items	
Specific activities for nontimber purposes	$9.84
General nontimber objectives	7.68
Cost effect on bid difference, specific activities	8.40
	$25.92/M bd ft

It should be emphasized, however, that this is an average for 187 sample sales; on any one sale the effects would probably vary considerably. This $26/M bd ft represents about 18 percent of the $144/M bd ft average logging costs of the sample sales, and about 7 percent of the final product value of $340/M bd ft (log scale). Because purchasers bid an average of $107/M bd ft on the sample sales, the estimated nontimber costs were equal to about a quarter of the bid price.

The estimated effects of nontimber considerations on appraisal allowance and bid difference, as summarized in the above tables and discussion, are probably a reasonable approximation of average conditions for the sample sales during the time period covered. It should be recognized, however, that current and future sales may have characteristics and requirements different from those included in this study and may reflect experience gained in meeting nontimber goals over the past decade. It should also be recalled from the introduction that the costs analyzed here do not include costs of Forest Service administration and do not reflect opportunity costs of alternative management practices for the forest land.

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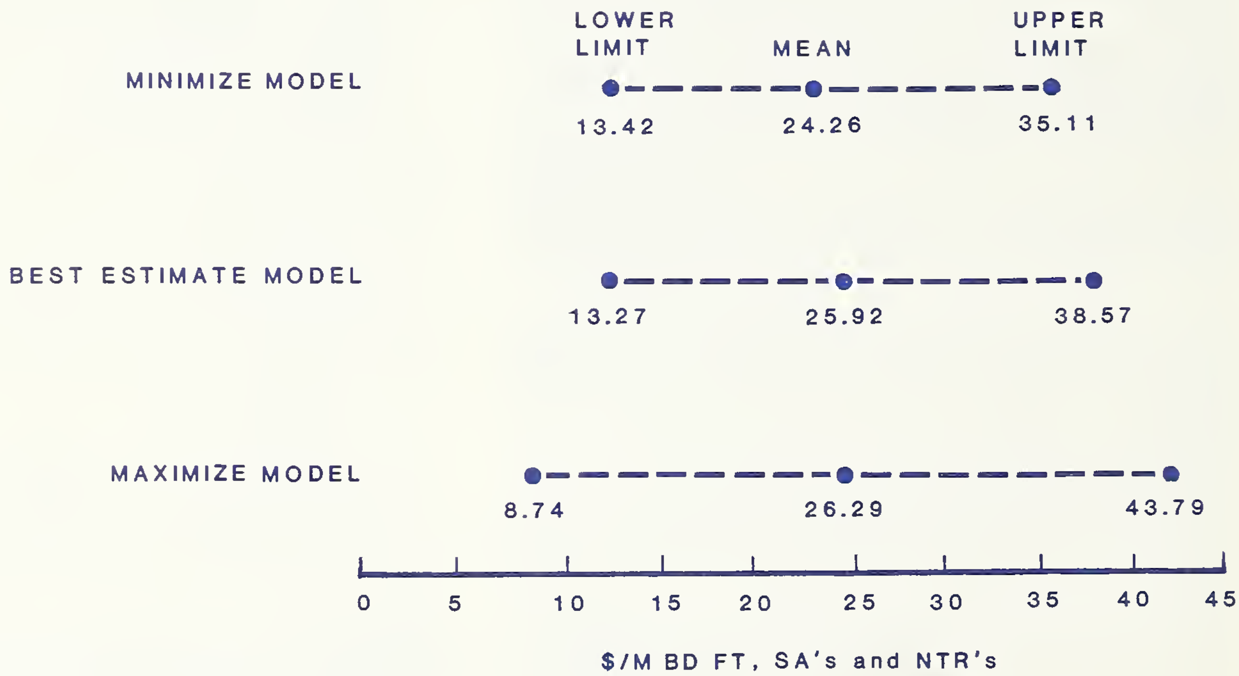
APPENDIX A: CONFIDENCE INTERVAL FOR ESTIMATED COSTS OF SPECIFIC ACTIVITIES AND NONTIMBER REQUIREMENTS

In the text, three modeling approaches (philosophies) were used to derive a range of estimates of the costs of specific activities (SA's) and nontimber requirements (NTR's). A standard approach of showing variation (range) around an estimate is to use confidence intervals. The general confidence interval used is the following:

$$\hat{Y} \pm t_{\alpha,n} \times \text{standard error}$$

By selecting an alpha value (α), the confidence level of the interval is set. In the following graph the 95 percent confidence interval ($\alpha = 0.05$) around the predicted costs of combined specific activities and nontimber requirements is presented for each of the three modeling approaches.



APPENDIX B: SUMMARY STATISTICS FOR SAMPLE TIMBER SALES

Table 16.—Timber sale characteristics, 187 sample sales, northern Idaho and western Montana

Description of variable	Name	Unit	Mean	SD	Min.	Max.
Total volume	TOTVOL	MM bd ft	8.209	5.479	1.18	27.930
Volume per acre	VOL/A	M bd ft	16.0	8.0	2.2	51.7
Total acres harvested	TOTAC	acre	540.5	348.82	74	1,597
Logs per M bd ft	LOGM	number	17.99	7.44	5.10	47.90
Paved haul distance	PAVEHAUL	mile	23.03	18.24	0	84.80
Unpaved haul distance	UNPAVEHAUL	mile	13.37	10.25	0.10	44.00
Mean acres in cutting units	MEANAC	acre	49.86	42.82	6	258
Number of cutting units	NCU	number	15.3	10.3	1	50
Road construction	CONST	mile	6.3	5.9	0	30.8
Road reconstruction	RECON	mile	5.6	5.6	0	23.9

Table 17.—Timber sale cutting methods, percent of sale area, 187 sample sales, northern Idaho and western Montana

Description of variable	Name	Unit	Mean	SD	Min.	Max.
Clearcut	CC	percent	38.28	32.40	0	100
Group selection	GPSEL	percent	2.44	12.61	0	94
Partial cut	PARTCUT	percent	58.97	33.41	0	99

Table 18.—Timber sale yarding method, 187 sample sales, northern Idaho and western Montana

Description of variable	Name	Unit	Mean	SD	Min.	Max.
Tractor log area	TLOGA	percent	62.87	32.21	0	99
Skyline area	SKYA	percent	18.14	26.60	0	99
Jammer log area	JLOGA	percent	17.72	25.98	0	94

Table 19.—Timber sale logging specific activities and requirements undertaken or modified for nontimber resources

A. CONTINUOUS VARIABLES

Description of variable	Name	Unit	Mean	SD	Min.	Max.
Directional felling	FELLO	percent of area	67.38	44.74	0	99
Road grade	RDGRADE	percent grade	9.14	2.27	4	15
Skid slope grade	SKIDSLO	percent slope	37.43	7.67	0	65
Closure barriers	CLOSBAR	number	1.54	4.05	0	30

B. PRESENT OR ABSENT (1,0)

Requirements	Name	Proportion of sales
Road width other than normal	RDWID	0.171
Special cut and fill	CUTSEM	.089
Special road activities	ORA	.171
Road spacing restricted	SPACE	.206
Corridor width constrained	CORWID	.278
Whole-tree logging	WHOT	.102
Snow removal required	SNOW	.182
Other nontimber requirements	ONTR	.118

Table 20.—Timber sale general nontimber resource consideration (present, absent 1.0 variables)

Description of variable	Name	Proportion of sales present
Soil plan (map, etc.)	SOPLAN	0.866
Logging modified to protect soil	SOACT3	.187
Visual quality objective in plan	VQO	.428
Cultural features or activities in plan	CULPLAN	.695
Wildlife plan for deer and elk	WPD&E	.775
Wildlife food protected or enhanced	WLFOOD	.337
Wildlife travel zone protected	WLTRAVEL	.059
Miscellaneous other wildlife considerations	WLOTH	.214

Benson, Robert E.; Niccolucci, Michael J. Costs of managing nontimber resources when harvesting timber in the Northern Rockies. Research Paper INT-351. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1985. 22 p.

Some 187 Forest Service timber sales in western Montana and northern Idaho were analyzed to determine the costs of protecting or enhancing nontimber resources during timber harvesting. Linear regression models were used to estimate how various activities undertaken to meet nontimber concerns affected costs for various phases of logging, and also the bids for stumpage. Costs of managing nontimber resources averaged $26 per thousand board feet of stumpage sold.

KEYWORDS: costs, harvesting, nontimber resources, logging costs, timber appraisals, bidding

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